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GENERAL SCIENCE.—*Report of the committee on the 1929 revision of the Academy's list of one hundred popular books in science.* PAUL R. HEYL, Chairman.

The following books, 17 in number, are now out of print, and have consequently been removed from the list:

GENERAL WORKS.

Curtis, Winterton C.	Science and human affairs.

SCIENCES OF MAN.

ANTHROPOLOGY

Mason, O. T.	The origins of invention.
Hough, Walter	The Hopi Indians.

SCIENCES OF LIFE.

GENERAL BIOLOGY

Thomson, J. Arthur	The haunts of life.

ZOOLOGY

Stone, Witmer, and Cram, W. E.	American animals.
Mayer, Alfred G.	Sea-shore life.

BOTANY

Darwin, Charles	Insectivorous plants.

SCIENCES OF THE EARTH.

THE EARTH'S SURFACE

Bonney, T. G.	The work of rains and rivers.
Bonney, T. G.	Volcanoes.

THE AIR AND THE OCEAN

Humphreys, W. J.	Weather proverbs and paradoxes.
Talman, C. F.	Our weather.

SCIENCES OF THE HEAVENS.

Ball, Robert S.	The story of the heavens.
Dyson, F. W.	Astronomy.
Abbott, Charles G.	The sun.

SCIENCES OF THINGS AND EVENTS.

PHYSICS

Boys, C. V.	Soap bubbles.
Mach, Ernst	Popular scientific lectures.

SCIENCES OF FORM AND RELATIONS.

DeMorgan, Augustus	On the study and the difficulties of mathematics

The following books, 13 in number, have been recommended for removal from the list by different members of the Committee, as later books are now available giving a more up-to-date view of the subjects:

SCIENCES OF MAN.

ANTHROPOLOGY

Wissler, Clark	Man and culture.
Haddon, A. C.	The races of man.

HUMAN PHYSIOLOGY

Huntington, Ellsworth	Civilization and climate.

SCIENCES OF LIFE.

ZOOLOGY

Beebe, C. W.	Jungle peace.
Bouvier, E. L.	The psychic life of insects.
Fabre, J. H.	Social life in the insect world.

BOTANY

Hardy, M. E.	The geography of plants.

ANCIENT LIFE

Lucas, F. A.	Animals of the past.

SCIENCES OF THE EARTH.

Gregory, J. W.	Geology of to-day.
Lull, R. S., and others.	The evolution of the earth and its inhabitants.
Cole, Grenville A. J.	Rocks and their origins.
Merrill, George P.	The first one hundred years of American geology.
Brigham, Albert T.	Geographic influence in American history.

To replace the foregoing, the following thirty books have been recommended by members of the Committee:

A GENERAL VIEW.

Huxley, Julian. *Essays in popular science.*
(Alfred A. Knopf, New York, 1927.)

Bragg, Sir William. *Creative knowledge.*
(Harper & Brothers, New York, 1927. 258 pp.)
Simple explanations of fundamental principles of such industries as those of the sailor, the potter, the miner, the dyer, the weaver, and the smith, with illustrations of the primitive development of these trades. What everybody ought to know but what few do.

Newman, H. H., and others. *The nature of the world and man.*
(University of Chicago Press, 1926.)
A series of articles by members of the faculty of the University of Chicago describing the modern view of Nature in its different aspects.

SCIENCES OF MAN.

ANTHROPOLOGY

Wissler, Clark. *The American Indian.*
(Douglas C. McMurtrie, New York, 1917. 435 pp., illus.)
Deals with the types, environments, habits, customs, and other phases of Indian culture.

Hough, Walter. *The story of fire.*
(Doubleday, Doran & Co., New York, 1928. 198 pp. and 30 illus.)

Hrdlička, Aleš. *The old Americans.*
(Williams & Wilkins Co., Baltimore, 1925. 438 pp., illus.)
Studies the old American stock, its history, formation,

characteristics, changes in the New World, and discusses the evolution of a new American type.

Kroeber, A. L. *Anthropology.*
(Harcourt, Brace & Co., New York, 1923. 523 pp.)

SCIENCES OF LIFE.

HEREDITY

Jennings, H. S. *Prometheus.*
(E. P. Dutton & Co., New York, 1925.)
A brief discussion of heredity in relation to man.

GENERAL BIOLOGY

Haldane, J. B. S. *Possible worlds.*
(Harper & Brothers, New York, 1928. 305 pp.)
Deals with a number of biological problems in relation to man.

Mason, Frances (Editor). *Creation by evolution.*
(The Macmillan Co., New York, 1928. 392 pp.)
A collection of chapters on evolution in non-technical language by twenty-five leading biologists and zoologists of England and the United States. Admirably adapted for giving modern views of the various phases of the question.

ZOOLOGY

Beebe, Charles William. *Beneath tropic seas.*
(G. P. Putnam's Sons, New York, 1928. 234 pp. and 60 illus.)
The author gives in a popular form the high lights of an expedition to Haiti to study the Haitian fishes and the life of a coral reef at close range by means of a diving helmet and motion pictures taken in the water.

Wheeler, William Morton. *The social insects.*
(Harcourt, Brace & Co., New York, 1928. 378 pp. and 79 illus.)
Twelve lectures delivered at the University of Paris. Deals with the scope and meaning of the social among insects, with polymorphism and the evolution of wasps, bees, ants, and termites, and the evolution of the guests and parasites of social insects.

Forel, Auguste. *The social world of the ants.*
(G. P. Putnam's Sons, New York, 1928. Vol. 1, 551 pp. and 95 illus.; vol. 2, 445 pp. and 138 illus.)
Summing up a century of research on the anatomy, physiology, and psychology of the ants, the author elucidates a philosophy of the biological problems of man by the sensory and instinctive behavior of the ants. Forel's large work may remain a classic in the same sense as Darwin's "Origin of species."

BOTANY

Bower, O. F. *Plants and man.*
(The Macmillan Co., New York, 1925. 365 pp., illus.)
A popular or semi-popular book written by a recognized authority. It is correct and sound botanically and also readable and interesting.

Berry, Edward Wilber. *Tree ancestors—a glimpse into the past.*
(Williams & Wilkins Co., Baltimore, 1923. 270 pp. and 48 illus.)

Rolfe, R. T., and Rolfe, F. W. *The romance of the fungus world.*
(Chapman & Hall, Ltd., London, 1925.)
An account of fungus life in its numerous guises, both real and legendary.

MICROSCOPIC LIFE

DeKruif, Paul. *Microbe hunters.*
(Harcourt, Brace & Co., New York, 1929.)
A history of the development of our knowledge of micro-organisms in relation to disease; centers around the leading figures in this field of biology.

ANCIENT LIFE

Knowlton, Frank H. *Plants of the past.*
(Princeton University Press, 1927. 275 pp. and 90 illus.)
A popular and scientific account of the appearance and progress of plant life on the earth.

SCIENCES OF THE EARTH.

Cleland, H. F. *Geology, physical and historical.*
(American Book Co., New York, 1916. 718 pp., illus.)
A treatise on geologic science as a whole on a scale adequate for the general reader.

Lee, Willis T. *Stories in stone.*

(D. Van Nostrand Co., New York, 1926. 226 pp. and 52 illus.)

Chapters on various geologic topics, such as the Grand Canyon, ancient landscapes, Triassic, Jurassic, and Cretaceous scenes, in non-technical language.

Brewster, Edwin T. *This puzzling planet.*

(Bobbs-Merrill Co., Indianapolis, 928. 328 pp., illus.)

Similar to "Stories in stone."

Schuchert, Charles, and LeVene, Clara M. *The earth and its rhythms.*

(Appleton & Co., New York, 1923. 385 pp.)

Similar to "Stories in stone" in general plan but more comprehensive.

Geikie, Sir Archibald. *The founders of geology.*

(The Macmillan Co., New York, 1905. 468 pp.)

A very interesting account of the growth of geologic knowledge from antiquity to the present, with biographic sketches of the men who have contributed most to the building of the science.

THE EARTH'S SURFACE

Bowman, Isaiah. *Forest physiography.*

(J. Wiley & Sons, New York, 1911. 759 pp., illus.)

Treats of physiography and physiographic regions of the United States, especially in their relations to forestry.

Henderson, Junius B. *Geology in its relation to landscape.*

(The Stratford Co., Boston, 1925. 152 pp., illus.)

Treats in popular style of the relations of landscape to the character and structure of the underlying rock formations.

SCIENCES OF THE HEAVENS.

Abbot, C. G. *The earth and the stars.*

(D. Van Nostrand Co., New York, 1925.)

This book is for non-technical readers, and not for the professional astronomer. It has been the aim of the author to present the most salient of the facts in simple words, and in such relations as will display our present views of why and how the celestial host came to be as it is.

SCIENCES OF THINGS AND EVENTS.

PHYSICS

Eddington, A. S. *The nature of the physical world.*
(The Macmillan Co., New York, 1929. 353 pp.)
A comprehensive discussion of the new physical conceptions and their philosophical consequences as seen by the chief British exponent of Einstein's theory of relativity. Gives in non-mathematical language the new views of gravitation, the quantum theory, the non-Euclidian geometry and the wave theory of matter.

Bragg, Sir William. *Concerning the nature of things.*
(Harper & Brothers, New York, 1925. 249 pp.)
An explanation of the modern conceptions of the constitution of matter, especially the structure of crytals, to which field the author has been a foremost contributor.

Heyl, Paul R. *Fundamental concepts of physics.*
(Williams & Wilkins Co., Baltimore, 1926.)
A summary of the development of physical thought and experiment from the eighteenth to the twentieth century.

SCIENCES OF FORM AND RELATION.

Cajori, Florian. *History of mathematics.*
(The Macmillan Co., New York, 1919. 514 pp., illus.)
This book has for years been the standard work on the subject in English. Well classified and readable.

The complete list, omitting descriptive paragraphs, is as follows:

A GENERAL VIEW.

1. Huxley, Thomas Henry	Selections from Huxley.
2. Huxley, Julian	Essays in popular science.
3. Bragg, Sir William	Creative knowledge.
4. Newman, H. H., and others	The nature of the world and man.
5. Slosson, Edwin E.	Keeping up with science.

SCIENCES OF MAN.

PSYCHOLOGY

6. Thorndike, Edward L.	The human nature club.
7. James, William	Psychology.
8. Woodworth, Robert S.	Psychology; a study of mental life.

ANTHROPOLOGY

9. Osborn, Henry Fairfield	Men of the old stone age.
10. Wissler, Clark	The American Indian.
11. Hough, Walter	The story of fire.
12. Hrdlička, Aleš	The old Americans.
13. Kroeber, A. L.	Anthropology.

HUMAN PHYSIOLOGY

14. Sherman, H. C.	Food products.
15. Eddy, Walter H.	The vitamine manual.
16. Jordan, E. O.	Food poisoning.
17. Keen, William Williams	Medical research and human welfare.

SCIENCES OF LIFE.

HEREDITY

18. Darwin, Charles	The origin of species.
19. East, E. M., and Jones, D. F.	Inbreeding and outbreeding.
20. Castle, W. E., Coulter, J. M., Davenport, C. B., East, E. M., and Tower, W. L.	Heredity and eugenics.
21. Conklin, E. G.	Heredity and environment.
22. Galton, Francis	Hereditary genius.
23. Popenoe, Paul, and Johnson, R. H.	Applied eugenics.
24. Jennings, H. S.	Prometheus.

GENERAL BIOLOGY

25. Thomson, J. Arthur.	The wonder of life.
26. Lucy, William A.	Biology and its makers.
27. Haldane, J. B. S.	Possible worlds.
28. Mason, Frances (Editor)	Creation by evolution.

ZOOLOGY

29. Buckley, A. B.	The winners in life's race.
30. Nelson, E. W.	Wild animals of North America.

31.	Roosevelt, Theodore	African game trails.
32.	Chapman, Frank M.	Camps and cruises of an ornithologist.
33.	Maeterlinck, Maurice	The life of the bee.
34.	Jenkins, Oliver P.	Interesting neighbors.
35.	Blatchley, W. S.	Gleanings from nature.
36.	Beebe, Charles William	Beneath tropic seas.
37.	Wheeler, William Morton	The social insects.
38.	Forel, Auguste	The social world of the ants.

BOTANY

39.	Ganong, W. F.	The living plant.
40.	Osterhout, W. J. V.	Experiments with plants.
41.	Sorauer, Paul	A popular treatise on the physiology of plants.
42.	Towsend, C. W.	Sand dunes and salt marshes.
43.	Bower, F. O.	Plants and man.
44.	Berry, Edward Wilber	Tree ancestors.
45.	Rolfe, R. T., and Rolfe, F. W.	The romance of the fungus world.

MICROSCOPIC LIFE

46.	Vallery-Radot, Réné	Louis Pasteur, his life and labours.
47.	DeKruif, Paul	The microbe hunters.

ANCIENT LIFE

48.	Knowlton, F. H.	Plants of the past.
49.	Hutchinson, H. N.	Extinct monsters and creatures of other days.

SCIENCES OF THE EARTH.

50.	Cleland, H. F.	Geology, physical and historical.
51.	Hawkesworth, Hallam	The strange adventures of a pebble.
52.	Lee, Willis T.	Stories in stone.
53.	Brewster, Edwin T.	This puzzling planet.
54.	Schuchert, Charles and Levene, Clara M.	The earth and its rhythms.
55.	Geikie, Archibald	The founders of geology.
56.	Semple, Ellen Churchill	Influences of geographical environment.

57. Spurr, J. E. (Editor) — Political and commercial geography of the world's mineral resources.

THE EARTH'S SURFACE

58. Bowman, Isaiah — Forest physiography.
59. Tyndall, John — The forms of water in clouds and rivers, ice and glaciers.
60. Henderson, Junius B. — Geology and the landscape.
61. Russell, Israel C. — Volcanoes of North America.
62. Davison, Charles — The origin of earthquakes.

THE AIR AND THE OCEAN

63. Brooks, Charles F. — Why the weather?
64. Ward, R. deC. — Climate, considered especially in relation to man.
65. Murray, John — The ocean.

SCIENCES OF THE HEAVENS.

66. Abbot, Charles G. — The earth and the stars.
67. Hale, George S. — The new heavens.
68. Lewis, Isabel M. — Splendors of the sky.
69. Murphy, E. G. (Kelvin McKready, pseud.) — A beginner's star book.
70. Turner, H. H. — A voyage through space.
71. Berry, Arthur — A short history of astronomy.

SCIENCES OF THINGS AND EVENTS.

CHEMISTRY

72. Slosson, E. E. — Creative chemistry.
73. Hendrick, Ellwood — Everyman's chemistry.
74. Fuller, Henry C. — The story of drugs.
75. Fabre, Jean Henri — The wonder book of chemistry.
76. Duncan, Robert Kennedy — The chemistry of commerce.
77. Martin, Geoffrey — Modern chemistry and its wonders.
78. Soddy, Frederick — The interpretation of radium.
79. Venable, F. P. — A short history of chemistry.
80. Smith, Edgar Fahs — Chemistry in America.

PHYSICS

81. Soddy, Frederick — Matter and energy.
82. Mills, John — Within the atom.

83.	Einstein, Albert	Relativity.
84.	Fleming, J. A.	Waves and ripples in water, air and aether.
85.	Miller, Dayton C.	The science of musical sounds.
86.	Bragg, William	The world of sound.
87.	Luckiesh, M.	Color and its applications.
88.	Soddy, Frederick	Science and life.
89.	Eddington, A. S.	The nature of the physical world.
90.	Bragg, Sir William	Concerning the nature of things.
91.	Heyl, Paul R.	Fundamental concepts of physics.

SCIENCES OF FORM AND RELATION.

92.	Ball, W. W. Rouse	Mathematical recreations and problems.
93.	Whitehead, A. N.	Introduction to mathematics.
94.	Conant, Levi Leonard	The number concept, its origin and development.
95.	Young, John Wesley	Lectures on the fundamental concepts of algebra and geometry.
96.	Cajori, Florian	A history of mathematics.
97.	Smith, David Eugene	Number stories of long ago.

HISTORY OF SCIENCE.

98.	Libby, Walter	An introduction to the history of science.
99.	Sedgwick, W. T., and Tyler, H. W.	A short history of science.
100.	White, Andrew D.	A history of the warfare of science with theology in Christendom.

EVOLUTION.—*Zoogenesis.*[1] AUSTIN H. CLARK, U. S. National Museum.

It is a readily demonstrable fact that every living thing is the child of some other living thing. It is utterly impossible for any living thing to appear spontaneously. Since all living things are derived from other living things, it naturally follows that the ancestral line of every living thing in the world at the present time has been continuous and unbroken, going back to the very earliest life upon the earth. No biologist at the present day doubts the continuity of life from parent

[1] Received April 5, 1929.

to child through all the ages that have passed since life's first beginnings, or the common origin of all forms of life.

Every living thing develops from a particle of living matter—a single germ cell—in which no trace of the adult form of that living thing is discernible. Since every animal, no matter what it is, originates as a single cell, we are safe in assuming that all types of animal life must be explained in terms of a primitive single cell.

The course of development of animal forms from those whose body is composed of a single cell to the multitudes of multicellular types which we know today is explained by what is called the theory of evolution.

Evolution as commonly understood assumes the gradual development step by step of all the widely varying forms of animal life from an original form of simple structure. But the developmental course which has been followed by animal life can not be reduced to any such simple formula. There are three separate sets of facts to be considered, and any acceptable theory of animal development must harmonize and correlate all three.

In the first place, within each of the so-called phyla or major groups of animals, as is well seen in the vertebrates, particularly in the mammals and the reptiles, there are many well marked, obvious, and undeniable evolutionary lines which, beginning with a relatively simple form of creature, run by easy stages to a specialized and highly complex form.

In the second place, very few of these evolutionary lines are perfectly continuous. Practically all of them are more or less frequently interrupted by gaps of various widths, and these gaps are often very broad. Especially is it true that these evolutionary lines tend to be separated from each other for their entire course, running parallel right down to their very earliest beginnings and not converging to a common type of animal as we would expect. For instance, the cat line and the dog line are always separate. No forms intermediate between cats and their relatives and dogs and their relatives are known, although both cats and dogs are collateral members of that great group of mammals known as the Carnivora and therefore must have had a common ancestor. Similarly, there are no intermediates between turtles and snakes, or between turtles and lizards, all of which are reptiles, or between squid and oysters, though both types are mollusks.

In the third place, no animals are known even from the very earliest rocks which can not be at once assigned to their proper phylum or major group on the basis of the definition of that group as drawn up

from a study of living animals alone. A backboned animal is always unmistakably a backboned animal, a starfish is always a starfish, and an insect is always an insect no matter whether we find it as a fossil in the rocks or catch it alive at the present day. There can be only one interpretation of this entire lack of any intermediates between the major groups of animals, as for instance between the vertebrates, the echinoderms, the mollusks and the arthropods. If we are willing to accept the facts at their face value, which would seem to be the only thing to do, we must believe that there never were such intermediates, or in other words that these major groups from the very first bore the same relation to each other that they do at the present day. Is this creationism? Not at all. It simply means that life at its very first beginnings from the single cell developed simultaneously and at once in every possible direction. All of the phyla or major groups seem to be of simultaneous development—at least we have no evidence that it was otherwise. From each one of these after its appearance a separate evolutionary tree arose, growing upward through the ages.

The numerous developmental lines are explained by the process of *evolution* as that term is commonly understood, and this descriptive word should be restricted to these developmental lines.

The gaps within these lines, and between related lines which run more or less parallel, are explained by an extension of the theory of *mutations*.

The complete absence of any intermediate forms between the major groups of animals, which is one of the most striking and most significant phenomena brought out by the study of zoology, has hitherto been overlooked, or at least ignored. This condition may readily be explained from an application of the facts gained through the study of embryology by a theory which may be called the theory of *primagenesis*.

Restriction or expansion of the meaning of a well known word results always in confusion. The term evolution is commonly used to cover the entire developmental history of animals. But evolution contemplates a gradual and continuous unfolding of animal life beginning with creatures consisting of a single cell and ending with man. A better understanding of the subject will result if we recognize the fact that this process includes three distinct but interrelated phases, first, *evolution* properly so called; second, *mutations;* and third, *primagenesis*.

If we regard the complete history of the development of animal life in this light, we must, in order to avoid confusion, use for it an entirely new term. We may call it *zoogenesis*.

Evolution

To illustrate evolution as here restricted, let us briefly review the history of the mammals and the reptiles, bearing in mind that similar histories are found in many other less familiar forms of life.

The reptiles first appeared in that very ancient time which is known to geologists as the Carboniferous and gradually increased in diversity and in maximum size. The largest land animals of which we have any knowledge are the largest of the dinosaurs which flourished in those periods known as the Jurassic and Cretaceous. At the end of the Cretaceous period most of the larger and more spectacular of the reptiles suddenly disappeared, but many reptilian types, for instance the turtles, lizards, snakes and crocodilians, continued right through to the present day.

The mammals first appeared in the form of very small and insignificant creatures at the time when the great reptiles were the dominating giants of the land and sea. After the sudden disappearance of the giant reptiles they increased greatly in diversity and somewhat in size, though in the earlier portion of the epoch following (Eocene) the largest mammal was not so large even as a sheep.

These mammals of the earlier portion of the "dawn period" (Eocene) soon disappeared; but as they disappeared their place was taken by other types which were more or less comparable to the sorts we know today. Gradually as time went on these mammals became more and more diversified. Various extraordinary types, some of huge size, appeared and not long afterwards disappeared, while together with these came others which we have no difficulty in recognizing as the direct predecessors of the types we know at the present day.

In order to make the picture clearer let us narrow our perspective and focus our attention on the horses. In the Eocene we find a curious little creature no bigger than a fox called the "dawn horse"—*Eohippus*. This had four toes on the front and three on the hind feet and a relatively short head with the eyes about half way between the ears and the tip of the nose instead of nearer the ears than the tip of the nose as in the later horses.

Following the "dawn horse" we find a number of different kinds of horses mostly about the size of a shepherd dog or a little larger, all of which had three toes. Like the "dawn horse" and its relatives, they had low crowned teeth which were affixed to the jaw by means of roots.

Still later there are horses which as colts had low crowned teeth, but

when fully grown had teeth with fairly high crowns. With these lived others in which the teeth had high crowns at all ages. These horses had shorter muzzles and rather less deep jaws than the modern horse, and while they had a single hoof there was a toe on either side of it. These lateral toes varied from small ones which did not reach the ground to larger ones which reached the ground. Though these were larger than their predecessors, they were not so large as the later horses.

In the Pleistocene or Ice Age we had in North America many different kinds of horses which were all of the modern type with long high crowned teeth and deep jaws. They ranged in size from little ones no bigger than the smallest Shetland pony to some which were larger than the largest draught horses. Before the discovery of America by the Europeans all of these had disappeared, for what reason we do not know.

There is an interesting and significant correlation between the interrelationships of animal types at the present day, their life history, and their fossil record which, though of the greatest importance from the point of view of animal evolution, seems never to have been pointed out.

Among the vertebrates the least diversified of the included classes is that which includes the birds while the most diversified is that which includes the fishes.

All birds exhibit a similarity in the broader features of their structure which, considering their numbers and the very great diversity in the minor structural details, is surprising. In conformity with this, birds in their embryonic stages and in their pre-adult existence exhibit a uniformity which is without parallel among the vertebrates.

All birds lay eggs which are enclosed within a rigid and at the same time brittle calcareous shell. There are among them no viviparous forms such as occur among the mammals, reptiles, fishes and amphibians. The eggs are always large, and are provided with abundant food material. From the egg the chick emerges in a well developed—sometimes in a very highly developed—stage.

In all birds except the megapodes the young are assiduously tended by their parents, or by one parent, until nearly or quite the full size is reached. In all birds the embryo develops within a rigid envelope permitting but little deviation from the general type represented by the parents. Furthermore, the young, dependent on the ministrations of one or both the parents, must be of such a nature as to be able to receive and to profit by parental care, and also to stimulate it. This

still further restricts the possibility of wide deviation from a general type.

So all the birds, both fossil and living, excepting for the ancient toothed birds and the *Archæopteryx*, are very closely allied and in spite of the vast range in size, from Princess Helen's hummingbird to the ostrich, the birds form a much more unified group than do the mammals, reptiles, amphibians or fishes.

In the vertebrates the interrelationships and the evolutionary history of the types in the several included classes are largely a reflection of the possibilities for variation afforded in the early stages. In the invertebrates this is even more striking as is at once brought out if we compare the insects with any one of the larger groups of marine invertebrates.

Mutations

The variability in the continuity of the evolutionary lines leads naturally to a consideration of mutations. While in many animal types we are able to trace, as in the horses, a gradual evolution from a form which is simple and generalized in structure to one or many forms which are highly specialized, this is by no means always true. Indeed, it is the exception rather than the rule.

Most lines are broken by curious gaps which may be small and insignificant, or broad and striking. It is commonly assumed that these various gaps are due to our lack of knowledge of the animals concerned, and especially of their fossil record.

No doubt in very many cases this is true, but in most cases these gaps probably are real and never were bridged by so-called "missing links."

In the light of our present knowledge we can not doubt that all living things are the children of other living things, and that life has been continuous from parent to child from its earliest beginnings. How is it possible to harmonize this fact with the occurrence of broad and unbridged gaps in the evolutionary lines?

The answer is that continuity of life does nor necessarily imply continuity of the bodily form in which that life is manifested. In other words, children may be very different from their parents. As an illustration of continuity of life coupled with abrupt and striking discontinuity of form and also in mental traits, let us consider the dogs.

According to the best authorities all of the nearly two hundred different breeds of domesticated dogs are descended from a single type of ancestor, which was a wolf closely resembling our native wolf but

with slightly different teeth. The domestic dogs may be grouped, following Gibson, into wolf-dogs, greyhounds, spaniels, hounds, mastiffs and terriers.

Some of the wolf-dogs, as the dogs of the Esquimaux and of the Kamchadales, show a more or less close resemblance to wolves, while others, as the collies, Newfoundlands and St. Bernards, are much less wolf-like. But the wolf-dogs may be arranged in a fairly continuous series from the most to the least wolf-like.

This series of dog forms is parallel to many of the evolutionary lines which are seen in the geological history of the mammals, as for instance in the horses and hyænas. It is a series of types which differ only very slightly from each other running between two extremes which are widely different.

Of the other breeds of dogs we may select the greyhounds, hounds, bull-dogs and pugs—the last two from the mastiff stock—as representative types known to every one.

It is not necessary here to describe the diverse bodily forms of these well known breeds of dogs. But their mental traits call for brief consideration. The greyhounds, or as they are sometimes called the "gaze-hounds," have deficient powers of scent but unusually keen eyes and ears. They hunt entirely by sight. There are many different forms of greyhounds. The hounds, having poor sight, hunt by scent, and they are also divided into many different forms. Bull-dogs are deficient both in sight and scent and are stupid and ferocious, displaying little affection. Pugs, which are much like bull-dogs and are equally stupid, differ markedly from them in being timid and affectionate.

There are no intergrading types between the greyhounds, the hounds, the bull-dogs and the pugs, and there are no intergrades between any of these and wolves. If we did not know their ancestry we would never suspect that these types of dogs had anything to do with wolves. They furnish an excellent and obvious illustration of unbroken continuity of descent coupled with abrupt and wide changes in form and in mental attributes.

An understanding and appreciation of the conditions found among the dogs enables us to approach the problem of the relationship of man to the animal world.

Structurally and anatomically man is very close to the man-like or anthropoid apes. This is a readily demonstrable fact which is quite beyond dispute. But it is also beyond dispute that there is a sharp, clean-cut, and very marked difference between man and the apes.

Every bone in the body of a man is at once distinguishable from the corresponding bone in the body of any of the apes.

Furthermore, man differs very widely from the apes in the possession of articulate speech which enables him to accumulate knowledge in successive generations. He also differs in his use of fire and in his use of tools which, as is shown by the fossil record, have been human attributes from the very first. Besides this, so far as history and the study of modern races enables us to judge, he differs in his use of clothing and of ornaments.

The most important difference, however, is correlated with the fact that in man the ministrations of both parents are necessary in the raising of a family. A woman can not raise a family unaided. Interdependent with this we find in man a socially effective sentiment of love which creates and makes a unit of the family.

That family life was from the first a fundamental human institution would seem to be shown conclusively by the existence in all human races of taboos and laws directed toward the maintenance of the family. Taboos and laws are not, so far as we know, invented to mold society into new and preconceived forms, but on the contrary to correct evils recognized as possessing disruptive or destructive tendencies which from time to time appear.

All monkeys, so far as we know, live together in promiscuous hordes or troupes in which each female raises her own young unaided. Family attachments are not necessary and do not occur.

While man obviously belongs to the same division of the mammals as the apes, yet the differences between man and the apes seem to be too great ever to have been bridged by intermediate types. Of all the numerous fossils that have been found not a single one represents indubitably a "missing link."

Man appeared suddenly as a collateral line from the same general complex as the apes, but there is no evidence that he was ever one of them. Between man and the apes there is a gap, structural and psychological, of the same general nature as that, for instance, between the greyhounds and the bull-dogs. But while we know that the greyhounds and the bull-dogs are both descended from a wolf, a creature widely different physically and mentally from both types, we have no definite clue to the immediate ancestry of man.

The general features of human structure and anatomy were inherited, in accordance with the unbroken continuity of descent from parent to child, from some unknown ancestor common to all the

Primates, but so far as we have been able to discover not through an ape as we understand that term. The details of man's structure and his mentality are his alone.

Unbroken continuity of descent coupled with abrupt discontinuities or changes in bodily form is a common, striking, and well known phenomenon in most types of animal life. We must accord it a proper place in any theory dealing with zoogenesis.

PRIMAGENESIS

The problem presented by the interrelationships between the phyla or major groups of animals has until recently seemed wholly incapable of a logical solution. It has always been the chief stumbling block in the path of all theories of evolution, for no theory of the development of animal forms is tenable that does not definitely allocate the phyla each in a definite relationship with all the others.

Smellie in 1790 expressed the evolutionary concept prevalent in his day when he wrote:

> In the chain of animals man is unquestionably the chief or capital link. . . . . From him all the other links descend by almost imperceptible gradations from man to the minutest animalcule.

In 1811 Professor Meckel expressed his doubts regarding the truth of this so far as concerns the lower animals. He said:

> From these lowest Vertebrata to the highest, and to the highest forms among these, the comparison between the embryonic condition of the higher animals and the adult states of the lower can be more completely and thoroughly instituted than if the survey is extended to the Invertebrata, inasmuch as the latter are in many respects constructed upon an altogether too dissimilar type; indeed they often differ from one another far more than the lowest vertebrate does from the highest mammal.

In the sixties of the last century when that great scholar, Charles Darwin, was the commanding figure in biological thought his most formidable opponent in this country, was the equally learned scholar and brilliant and magnetic leader, Louis Agassiz.

Professor Agassiz' reputation has suffered in no small degree because of his outspoken opposition to Darwin's ideas on the subject of evolution. Yet his opposition is easily understood. While Darwin had an unusually extensive knowledge of the invertebrates, still his work in so far as it concerned evolution was the outcome of an exceptionally detailed knowledge of and intimate acquaintance with land inhabiting vertebrates.

Agassiz, on the other hand, had devoted his attention especially to invertebrates, including their larval stages, and to fishes. Among the invertebrate groups Darwinian evolution can not be made to apply, and it is scarcely more applicable to fishes. Agassiz realized this just as had Meckel fifty years before, and it is greatly to his credit that he was brave enough to uphold his convictions in the face of the strong tide of popular sentiment. But unfortunately neither he nor Meckel had any alternative hypothesis to offer.

The first clue to the true state of affairs was given through the discovery by the late Dr. Charles D. Walcott in the Middle Cambrian rocks of British Columbia of what are probably the most remarkable fossils ever found.

Through these fossils the wholly unexpected and astounding fact was brought out that so long ago as Middle Cambrian time the interrelationships between the various animal phyla were just the same as they are today. In the Middle Cambrian crustaceans were crustaceans, echinoderms were echinoderms, chætognaths were chætognaths, and annelids were annelids quite as unmistakably as they are in the present seas.

Since there has been no change whatever in the interrelationships of the animal phyla or major groups over this long period of geological history, why should we not assume that these interrelationships were the same at the very first appearance of life?

Such an assumption is open to the criticism that, while the fossils in the Cambrian rocks are the first that are adequately known, yet it is undoubtedly true that the Cambrian is much nearer to the present epoch than it was to the far distant time when life on earth began, so that conditions in the Cambrian are not necessarily those at the time of the origin of life.

The answer to this criticism is that since we know that the interrelationships between the phyla run back without any change whatever to the Cambrian, it is more logical to assume a continuation of these parallel interrelationships into the indefinite past than it is to assume, somewhere in the unknown pre-Cambrian ages, a change in the interrelationships, for which last assumption we have not the slightest evidence.

Since there is nothing to be learned bearing on the interrelationships of the phyla or major groups from a study of the fossils, we must rely on the data furnished by the study of embryology in order to solve this problem.

All animals living at the present time develop from a single cell. As this is true of every animal of which the development is known, we have no hesitation in assuming that it has always been true of every animal type. But this does not mean we must assume that the first animals to appear were all composed of single cells.

A single cell may divide in such a way that the two derivative cells are completely separated and drift or swim away independently of each other. This type of cell division, resulting in the complete separation of the derivative cells after each division, may continue indefinitely.

In the single-celled animals or protozoans this is what actually happens. A fully grown protozoan with a body consisting of a single cell divides into two independent animals, each with a body which in bulk is equal to half that of the parent. When these two reach full size they each divide into two in the same way, and the process is continued indefinitely.

But on the other hand a single cell may divide and after division the two resultant cells may remain in contact. Subsequent division after the same fashion will result in the formation of a mass of cells.

The question naturally arises, were the earliest animals composed of single cells, or were they composed of masses of cells, or did unicellular and multicellular animal types live together side by side as they do today?

It is commonly assumed that single-celled animals preceded the multicellular types in appearance. But can anyone give any reason for this assumption beyond the fact that in arithmetic—which is not zoology—the number one precedes the other numbers?

There is no basis whatever for assuming that complete separation of dividing cells is more primitive than adhesion of cells after division, or that it preceded adhesion. In fact, the great rarity of complete separation of cells after division in the animal world taken as a whole almost suggests that adhesion, not separation, is the primitive condition. Therefore the statement commonly made that the single celled animals or protozoans are the most primitive of the animals and preceded the multicellular types has nothing to support it. The only logical assumption, based on known facts, is that the appearance of unicellular and multicellular animal types was simultaneous—perhaps even that the latter appeared first.

Cells which after division remain in contact may adhere irregularly, resulting in the formation of a more or less unorganized mass. Such a

condition is characteristic of the great group of sponges in which many of the constituent cells are almost wholly independent of each other and suggest masses of protozoans packed closely together.

Cells which after division remain in contact may adhere regularly, resulting in the appearance of a series of geometrical forms. Regular division of cells followed by regular adhesion leads to the formation of a hollow ball of cells called a blastula. The blastula collapses, like a rubber ball with one side pushed in, into a cup with an outer and an inner layer of cells called a gastrula. The typical gastrula has an axis passing through the center of the opening and of the opposite pole, and the radii about this axis are everywhere the same—in other words the typical gastrula is radially symmetrical about its only axis.

If the radially symmetrical gastrula should become adult, there would result a radially symmetrical animal composed of two layers of cells of quite the same nature as a hydra or a sea-anemone.

The whole group of the Cœlenterata—hydras, corals, sea-anemones, sea-pens, hydroids, alcyonarians, gorgonians, antipatharians, jelly-fishes, and numerous other types—represent animals derived from a single cell through regular geometrical division.

As there is no reason to assume that irregular adhesion of cells necessarily preceded regular division and adhesion, there are no grounds for supposing that the cœlenterates are not as old as the sponges or the protozoans. The appearance of the protozoans, the sponges and the cœlenterates was presumably simultaneous. There is not the slightest evidence which would lead us to suppose that any one of these preceded any of the others. Each is the logical end product of a special type of cell division.

All other animals are always in some stage, and usually in the adult, bilaterally symmetrical with a more or less well marked head end at which are the main nervous centers, the chief sense organs, and the mouth. No matter how different they may be, all of these animals in the course of their development pass through a gastrula or comparable stage. This gastrula stage is the last stage common to them all, and following this stage they diverge in various directions. But since they all pass through a gastrula stage they are all reducible to the developmental line which, followed to its logical end, leads to the cœlenterates.

The key to the connection between the radially and the bilaterally symmetrical animals is furnished by four curious groups having a symmetry which is in part radial and in part bilateral. These four

groups consist of (1) types which by continuous budding produce a linear colony; (2) types in which the budding takes place internally within the original unit; (3) types which are solitary, each individual representing a dissociated cœlenterate unit; and (4) types which are colonial, though the individuals are independent of each other.

Between every two of these types there is another type which combines the characters of the one on either side, but shows no trace of radial symmetry. Thus between the types which by continuous budding produce a linear colony and the types in which the budding takes place internally we find a type which is segmented externally and also possesses internal budding (cœlomic budding); between the types in which the budding takes placed internally within the original unit and the types which are solitary, each individual representing a dissociated cœlenterate unit, we find a type which is solitary with internal budding, but no segmentation, and so on.

On the basis of their fundamental characters all of the animal phyla or major groups may be arranged in five successive series of four each, the outermost four being the four partially radial types mentioned. Such a figure shows each phylum as related more or less equally to four others, and more distantly to all the rest. As we pass from the outer to the inner series we find that the phyla become more and more complex, and also progessively less and less widely differentiated from each other.

The exact center of the figure is occupied by the vertebrates which combine the characters of the four groups immediately surrounding them (cephalochordates, balanoglossids, pterobranchiates and tunicates) but are not more closely related to any one of these than to the other three.

The details of this arrangment are very complicated and can not be described except in technical terms. For these details the reader is referred to the author's paper on *The origin of the vertebrates*.[2]

According to this interpretation the various phyla of bilaterally symmetrical animals are in effect recombinations of features which are inherent in animals taken as a whole, or in other words recrystallizations of the fundamental animal features which occur at every focal point where an animal type capable of existence may be reconstructed from the elements available in the general animal complex.

No appreciable time element is necessarily involved in such a process of recombination or recrystallization of fundamental animal features,

[2] This JOURNAL 13: 129–138. 1923.

so that at the very first appearance of life the animal world, so far as the phyla or major groups are concerned, probably was quite the same as it is today.

The figure formed by this recombination of elemental structural features into the various phyla represents the basic structure in which all of the evolutionary trees are rooted and from which they rise, one from each phylum, upward through succeding ages.

This interpretation of the origin of the various phyla as resulting from recombinations of characters inherent in animals as a whole supplies the key to the very sharp distinctions usually to be seen between the different classes in each phylum. For the principle of recombination seems to explain such sharp distinctions or very broad mutations as those between the starfishes, brittle-stars, sea-urchins, sea-cucumbers, and crinoids and their allies in the echinoderms; between the gastropods, bivalves, scaphopods, cuttle-fish and other types in the mollusks; and between the crustaceans, insects, spiders, and other forms in the arthropods. Coming down to finer divisions, it serves to explain the curious isolation of the skippers (Hesperioidea) in the Lepidoptera, and in the skippers the sharp difference between the megathymids and the other types.

SUMMARY

The picture which we get of the development of the animal world—of zoogenesis—from the preceding exposition and interpretation of the facts is that at the very first all of the numerous phyla came into being not successively but simultaneously by following different paths of development from the single cell. The process leading to the original appearance of the phyla—primagenesis—gives a result that at first sight appears to be creationism, though in reality it is very different.

Each of the phyla represents a recombination of characters inherent in animals as a whole in a form capable of meeting the requirements of animal existence, both in internal balance and in external contacts.

Apparently the focal points at which a balanced condition capable of survival and of meeting competition is attainable are rather few and are well separated from each other, for each of the phyla is widely different from all the rest.

The flat picture of animal life presented as the result of primagenesis serves as the ground from which various evolutionary trees, one for each phylum, rise upward through geologic time.

The larger phyla are divided into classes, and as a rule these classes are quite distinct each from the other and do not intergrade. Thus

in the mollusks we find pelecypods, scaphopods, solenogasters, gastropods and cephalopods; in the echinoderms there are starfishes, brittle-stars, sea-urchins, sea-cucumbers, crinoids, cystids and blastoids; and in the arthropods there are crustaceans, arachnids, myriopods and insects.

The distinctness of these classes each from the other probably is of the same nature as the much broader distinctions between the various phyla. That is, each class should be interpreted as a recombination within the phylum in every economically possible form of characters inherent in the phylum.

Within the classes the same phenomenon is again repeated in the different orders, as is especially well seen in the insects, crustaceans, mollusks and echinoderms. Abrupt discontinuities may be followed further into sub-orders, families, genera and species, in the last being evidenced by the so-called mutations.

It should perhaps be emphasized that discontinuities are much less marked within the phylum Vertebrata than they are in the large invertebrate phyla. But the entire structural range in all the vertebrates taken together is scarcely greater than that in certain single species of insects or crustaceans in different stages in their life history. The vertebrates possess such a delicately balanced complexity of internal structure, and as a result of their large size such a delicate adjustment to their environment, that variations brought about by a continuous series of slight changes and progressive minor readjustments are more suited to them than the sudden wide and abrupt discontinuities so frequent in invertebrate types.

Among the vertebrates well marked evolutionary lines are frequent and wide discontinuities are relatively rare; but the reverse is true in all the other phyla of comparable size.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE GEOLOGICAL SOCIETY

446TH MEETING

The 446th meeting of the Society was held at the Cosmos Club, January 9, 1929, President CAPPS presiding.

Program: W. H. BRADLEY: *Varves and the duration of the Eocene epoch.* ANNA I. JONAS: *Structure of the metamorphic belt of the central Appalachians.* The metamorphic folded belt of the Appalachians in the area from eastern Pennsylvania to North Carolina consists of a southeastern or Martic overthrust block lying west of the Coastal Plain sediments and, on the north-

west, the anticlinal uplifts and synclinal infolds of the Highland-Blue Ridge anticlinorium, bounded on the west by the Great Valley.

Both divisions are made up of closely folded rocks of pre-Cambrian and Paleozoic age that are broken by thrust faults, showing all gradations from broken recumbent anticlines to clean cut thrusts developed from them and low angle thrusts of the Scottish Highland type. The thrusts of the anticlinorium belong to the former, while the Martic thrust belongs to the latter class. The Martic thrust fault bounds a block of the earth's crust whose eastern part is covered by Coastal Plain sediments. Its linear extent has been traced from the edge of these sediments in eastern Pennsylvania southwest into North Carolina.

The great width of the Martic overthrust block in southern Virginia is in part due to the southeast curve of Coastal Plain sediments and to the southwest direction of normal Triassic faults that form its northwestern border throughout most of Virginia, as well as the westward advance of the overthrust mass. The southwest direction of Triassic faults transverse to the folds of the anticlinorium on the uplifted side of the normal faults have had the effect of cutting them off from east to west and of decreasing the width of this belt.

The Martic overthrust is of post-Ordovician age and may be as late as post-Mississippian or post-Pennsylvanian, corresponding in age to the thrusts in and west of the anticlinorium. It is cut by little-deformed granites that are absent in Pennsylvania and occur in small areas in Maryland. They are widespread only southwest of Central Virginia. They have true granitic texture and lack the metamorphism of the pre-Cambrian granoblastic igneous rocks. They cut only pre-Cambrian crystalline schists and intrusive relations give no positive evidence of their age. They may be epi-Ordovician or post-Carboniferous in age. The absence of definite proof of the post-Permian age of these granites and lack of their wide distribution in many parts of the area throw doubt on the hypothesis that they produced the force for Appalachian deformation. (*Author's Abstract.*)

H. S. WASHINGTON: *Bearing of the rocks of the Island of St. Paul on the structure of the Atlantic floor.*

447TH MEETING

The 447th meeting was held at the Cosmos Club January 23, 1929, President CAPPS presiding.

Program: FRANK WENNER: *Development of seismometry for recording distant earthquakes.*

A. L. DAY: *The activities of the Carnegie Institution in seismology.*

L. H. ADAMS: *The structure of the earth's crust as revealed by seismologic observations.*

448TH MEETING

The 448th meeting was held at the Cosmos Club February 13, 1929, President CAPPS presiding.

Program: A. C. SPENCER: *Geology of Santa Rita, New Mexico.*

W. B. LANG: *Subnormal temperature gradients in the Permian basin of Texas and New Mexico.* The first deep well temperature test made in the Permian Basin of Texas and New Mexico near the southeastern border indicated a normal gradient. Later (1923) it was noted that oil-well tests being

drilled in the Basin were running cool and that low gradients were to be expected. The first instrumental proof of this fact was demonstrated in 1925, and in 1926 a gradient in excess of one degree Fahrenheit for every 250 feet of descent was obtained in Ward County, Texas. Other tests in West Texas and southeastern New Mexico in the Basin continue to show low gradients, and it is believed this condition extends westward beyond the saline boundary. Also the Panhandle of Texas and western Oklahoma are known to run cool and some temperatures in Iowa subnormal. In contradistinction, the Bend Arch to the east of the Basin is warm and to the west of the Central Mineral Region normal.

From an average of worldwide observations temperature gradients of 60 to 70 feet per degree Fahrenheit are considered normal. Lower gradients may therefore be considered as subnormal and dependent on abnormal influences. The present normal gradient is, to a degree, an arbitrary figure and subject to the influence of additional investigations properly spaced in accordance with the needs of the problem rather than of chance opportunity.

The Permian Basin is a region of sedimentary deposition in which halite and anhydrite play a prominent part, also potash. Theories accounting for the depression of the isogeotherms depend on sedimentation or structural deformation; paleoclimatic conditions; radioactivity (β ray of potassium); chemical change—anhydrite-gypsum, secondary mineral changes, solution reactions, etc.; radiation and heat conduction (halite); degrees of rock saturation, etc., seem to be inadequate to a satisfactory explanation. There is need for further reliable temperature measurements in order to outline the subnormal area and to assign proper values to the factors that may have causal relationship. Continued temperature measurements are in progress with this end in view. (*Author's Abstract.*)

JAMES GILLULY: *A possible capture of one desert basin by another.* The geographic and hypsometric relations of Rush Valley and Tooele Valley, Utah, together with the peculiar three stage dissection of Soldier Creek fan while all the other fans of the valley show but two stages of dissection, are interpreted as consistent with pre-Bonneville integration of the drainage of Rush Valley with that of Tooele Valley. The peculiar channel form of Rush Lake and its position between two of the largest fans in Rush Valley are anomalies which are explicable on this hypothesis. Climatic fluctuations or Bonneville wave erosion are shown to be impossible alternatives to this hypothesis, and although earth movements could be conceived which would explain the observed features, they are considered improbable.

It is concluded that drainage integration between separate basins may well occur without access to the sea. (*Author's abstract.*)

449TH MEETING

The 449th meeting was held in the Assembly Hall of the Cosmos Club February 27, 1929, President CAPPS presiding.

Program: Prof. RICHARD M. FIELD, of Princeton University: *Observations on the geological history of Yellowstone Park.* Paper published in full in Am. Journ. Sci. (17) 99. March, 1929.

C. S. Ross: *Origin of the magnetite and associated rocks of Cranberry, N. C.* The Cranberry iron mine lies in Avery County, in western North Carolina, near the southwest border of the Cranberry folio and on the lower flank of a spur of Roan Mountain. The inclosing rock is the Cranberry granite of pre-Cambrian age.

The ore zone is made up of gneissoid rock composed of magnetite, hornblende, epidote, and other ferromagnesian minerals. This is cut by a pegmatite complex that branches and reunites in an intricate manner. The ores appear to have been formed in two stages. The first produced lean magnetite gneisses. Later these were intruded by pegmatite of normal composition, i.e., microcline and quartz. This pegmatite was first invaded and partly replaced by albite and quartz forming solutions and then by ferro-magnesian solutions that introduced first epidotized feldspar, hornblende, hedenbergite and finally magnetite. At the same time the lean magnetite gneisses were further enriched by magnetite and the commercial ores produced. At a later stage a very small amount of sulphides were introduced and calcite formed.

A. A. BAKER and J. B. REESIDE, JR.: *Some features of Permian sedimentation in northern Arizona and southern Utah.* In San Juan Valley and a zone north and south from it the Permian begins with a unit of interbedded marine limestone and red beds, followed by several alternations of red beds and thick, light-colored, cross-bedded sandstones. Various names have been applied. Eastward these units pass into a similar basal unit and a thick series of arkosic red beds, called Rico and Cutler formations, respectively. Westward the units pass into the formations constituting the Grand Canyon section—Supai red beds, Hermit red beds, Coconino sandstone, and Kaibab limestone. Still farther westward few or no red rocks are present. The red beds seem to have been derived chiefly from the east. The light-colored sandstones seem to have come from both northwest and southeast. Kaibab limestone is thickest in the west and fades into sandstone eastward. Over much of the region the Permian is underlain conformably by Pennsylvanian limestone and is overlain uncomformably by Lower Triassic beds. (*Author's abstract.*)

A. A. BAKER and JAMES GILLULY, *Secretaries.*

SCIENTIFIC NOTES AND NEWS

Mr. NEIL M. JUDD, Curator of American Archeology, U. S. National Museum, left Washington in mid-May to join Doctor A. E. DOUGLASS, of the University of Arizona, and Mr. LYNDON HARGRAVE, at Flagstaff, on an archeological reconnaissance of central Arizona in search of ruins from which burned timbers might be recovered. The Museum of Northern Arizona, at Flagstaff, Doctor Harold S. Colton, Director, is coöperating by loaning Mr. Hargrave, who assisted Doctor Douglass in earlier beam studies at Hopi villages and elsewhere in Arizona. The purpose of the present expedition, under the auspices of the National Geographic Society, is to bridge the single remaining gap in the tree ring chronology now being erected by Doctor Douglass and by means of which most pre-Spanish ruins of the Southwest can be absolutely dated. This season's investigations are in continuation of those conducted for the Society by Mr. Judd at Pueblo Bonito, New Mexico, during the years 1920–1927.

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